PATENT ABSTRACTS OF JAPAN
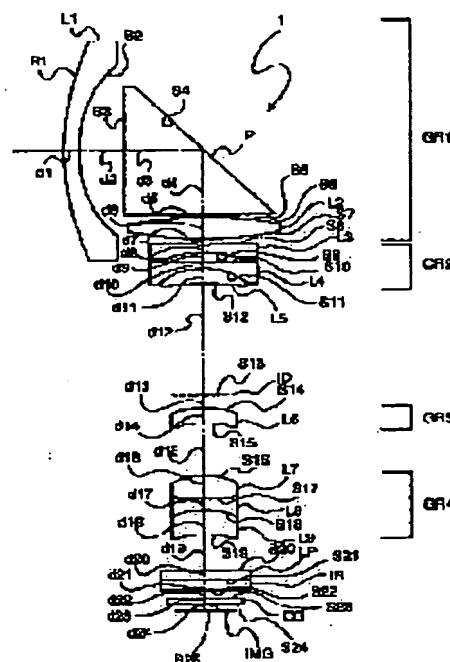
(54) ZOOM LENS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a small-sized zoom lens of about three-variable power ratio suitable for a small-sized image pickup device such as a video camera and a digital still camera, etc.
SOLUTION: The zoom lens 1 is constituted of a 1st lens group GR1 whose refractive power is positive, a 2nd lens group GR2 whose refractive power is negative, a 3rd lens group GR3 whose refractive power is positive and a 4th lens group GR4 whose refractive power is positive in order from an object side to an image field IMG side, and zooming is accomplished by moving the 2nd lens group GR2 and the 4th lens group GR4. In this case, the 1st lens group GR1 is constituted of a 1st single lens L1 whose refractive power is negative, a prism P for bending an optical path and a 2nd single lens L2 whose refractive power is positive in order from the object side.

LEGAL STATUS

[Date of request for examination]   05.07.2002

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]   3570253

[Date of registration]   02.07.2004

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] The 1st lens group which has forward refractive power in order from a body side to an image surface side, and the 2nd lens group which has negative refractive power, In the zoom lens it is made to have zooming performed by consisting of the 3rd lens group which has forward refractive power, and the 4th lens group which has forward refractive power, and moving the above-mentioned 2nd lens group and the 4th lens group The zoom lens with which the above-mentioned 1st lens group is characterized by being constituted with the 2nd lens of the 1st lens of the single lens which has negative refractive power, the prism with which an optical path is bent, and the single lens with which it has forward refractive power sequentially from a body side.

[Claim 2] The zoom lens according to claim 1 characterized by making it satisfy the following conditions.

$ndL1 > 1.75$ $nudL1 < 30$, however $ndL1$: −− the refractive index in d line of the 1st lens, and $nudL1$: −− it considers as the Abbe number in d line of the 1st lens.

[Claim 3] The zoom lens according to claim 1 characterized by constituting the field of at least 1 of the 1st lens according to the aspheric surface.

[Claim 4] The zoom lens according to claim 1 characterized by making into a convex the field it turned [field] to the body side of the 1st lens.

[Claim 5] The zoom lens according to claim 2 characterized by making into a convex the field it turned [field] to the body side of the 1st lens.

[Claim 6] The zoom lens according to claim 3 characterized by making into a convex the field it turned [field] to the body side of the 1st lens.

[Claim 7] The zoom lens according to claim 1 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according to the aspheric surface.

[Claim 8] The zoom lens according to claim 2 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according

to the aspheric surface.

[Claim 9] The zoom lens according to claim 3 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according to the aspheric surface.

[Claim 10] The zoom lens according to claim 4 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according to the aspheric surface.

[Claim 11] The zoom lens according to claim 5 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according to the aspheric surface.

[Claim 12] The zoom lens according to claim 6 characterized by constituting the at least 1st of each sides of the lens which constitutes the 4th lens group according to the aspheric surface.

[Claim 13] The zoom lens indicated to claim 1 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 14] The zoom lens indicated to claim 2 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 15] The zoom lens indicated to claim 3 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 16] The zoom lens indicated to claim 4 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 17] The zoom lens indicated to claim 5 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 18] The zoom lens indicated to claim 6 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1:lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 19] The zoom lens indicated to claim 7 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 20] The zoom lens indicated to claim 8 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 21] The zoom lens indicated to claim 9 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 22] The zoom lens indicated to claim 10 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 23] The zoom lens indicated to claim 11 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Claim 24] The zoom lens indicated to claim 12 characterized by satisfying the following conditions.

$4.5 < fGR1/fw < 12$ however the focal distance of the fGR1 :lens [1st] group, fw: Consider as the focal distance in the wide edge of the lens whole system.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the optimal zoom lens of variable
power ratio 3 double extent for a small video camera, a digital still camera, etc.

[0002]

[Description of the Prior Art] If it is in small image pick-up equipments, such as a
video camera and a digital still camera, in recent years, much more miniaturization
is called for and the lens for photography and the miniaturization according
[especially a zoom lens] to compaction of an overall length etc. are called for in
connection with this.

[0003] Moreover, if it is in the above-mentioned lens for photography, and the
thing for digital still cameras especially, the demand to a zoom lens including the
wide angle region whose field angle in a wide angle edge is about 70-80 degrees
is increasing with the miniaturization, and coincidence is asked also for
improvement in the lens engine performance corresponding to the raise in the
pixel of an image sensor.

[0004]

[Problem(s) to be Solved by the Invention] As a small zoom lens for small image
pick-up equipments, there is a zoom lens of 2 group configurations of the retro
focus type which consists of the 1st lens group which has a negative refractive
index, and the 2nd lens group which has forward refractive power sequentially
from a body side. However, if it is in the zoom lens of such 2 group configurations,
it is difficult to enlarge a variable power ratio, and since an overall length also
changes with zooming actuation, as a small object for image pick-up devices, it is
disqualified.

[0005] Moreover, there is a zoom lens of 4 group configurations which consist of
the 1st lens group which has forward refractive power, the 2nd lens group
(BARIETA) which has negative refractive power, the 3rd lens group (compensator)

which has forward refractive power, and the 4th lens group (master) which has forward refractive power sequentially from a body side. However, since an overall length becomes long, the zoom lens of such 4 group configurations is disqualified as a small object for image pick-up devices.

[0006] Furthermore, the 1st lens group which has forward refractive power sequentially from a zoom lens [which was indicated by JP,8-248318,A], i.e., body, side, Like the zoom lens of 4 group configurations which consist of the 2nd lens group (BARIETA) which has negative refractive power, the 3rd lens group (compensator) which has forward refractive power, and the 4th lens group (master) which has forward refractive power Arrange prism between the lenses of the location by the side of the body of the 1st lens group, and prism is inserted for the 1st lens group in between. Although there are some which shortened order length by bending an optical path with prism while dividing into the lens group which has forward refractive power in a body side at a negative and image surface side and constituting an afocal system This type of zoom lens had much configuration number of sheets of a lens, and, moreover, had the trouble that an overall length will also still be long and a manufacturing cost will also become high.

[0007] this invention -- the above-mentioned trouble -- taking an example -- the optimal variable power ratio for small image pick-up devices, such as a video camera and a digital still camera, -- let it be a technical problem to offer an about 3-time small zoom lens.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, this invention zoom lens The 1st lens group which has forward refractive power in order from a body side to an image surface side, and the 2nd lens group which has negative refractive power, In the zoom lens which was made to perform zooming by consisting of the 3rd lens group which has forward refractive power, and the 4th lens group which has forward refractive power, and moving the above-mentioned 2nd lens group and the 4th lens group The 2nd lens of the 1st lens of the single lens which has negative refractive power for the 1st lens group sequentially from a body side, the prism which bends an optical path, and the single lens which has forward refractive power constitutes.

[0009] therefore, the optimal variable power ratio for small image pick-up devices, such as a video camera and a digital still camera, -- it becomes possible to miniaturize an about 3-time zoom lens.

[0010]

[Embodiment of the Invention] Below, the gestalt of operation of this invention zoom lens is explained with reference to an accompanying drawing. In addition, as for drawing 1 thru/or drawing 4 , the gestalt (numerical example 2), drawing 9 , or

drawing 12 of the 2nd operation shows the gestalt (numerical example 3) of the 3rd operation, respectively, as for the gestalt (numerical example 1), drawing 5 , or drawing 8 of the 1st operation.

[0011] The common matter in introduction and the gestalt of each operation is explained.

[0012] In the following explanation, "Si" is counted from a body side. In addition, the i-th field, "Ri" The radius of curvature of the above-mentioned field Si, the spacing between the "di" body side to the i-th field, and the i+1st fields, In "ndLi", the Abbe number in d line of the i-th lens (Li) and "f" shall show the focal distance of the lens whole system, and, as for the refractive index in d line (wavelength of 587.6nm) of the i-th lens (Li), and "nudLi", "Fno." shall show an open F value and "omega" half field angle. However, as for that by which P, LP, IR, and CG were added after nd or nud, the refractive index or the Abbe number of cover glass of prism, a low pass filter, an infrared cut-off filter, and an image sensor shall be shown, respectively.

[0013] Moreover, that from which a lens side is constituted by the aspheric surface is also contained in the lens used in the gestalt of each operation.

[0014] If the radius of curvature in "x" and lens top-most vertices is set to "r" and it sets a cone constant to "kappa" for the depth (distance of the direction of an optical axis from the top-most vertices of a lens side) of the aspheric surface, an aspheric surface configuration $x=(y2/r)/1+(1-kappa-y2./r2)1/2+C4$, y4+C6, y6+C8 and y8+C10, and y10 shall define. In addition, C4, C6, C8, and C10 are the 4th aspheric surface multipliers [6th / 8th / 10th], respectively.

[0015] The zoom lenses 1, 2, and 3 in the 1st thru/or the 3rd example consist of the 1st lens group GR1 which has forward refractive power in order from a body side to an image surface IMG side, the 2nd lens group GR2 which has negative refractive power, the 3rd lens group GR3 which has forward refractive power, and the 4th lens group GR4 which has forward refractive power, as shown in drawing 1 , drawing 5 , and drawing 9 . The prism with which a zoom lens 1 thru/or 3 have been arranged in the meantime [two lenses and in the meantime] to which the 1st lens group GR1 changes from the 1st lens L1 and the 2nd lens L2, three lenses and the 3rd lens group GR3 to which the 2nd lens group GR2 changes from the 3rd lens L3, the 4th lens L4, and the 5th lens L5 -- 6th lens L6 -- and The 4th lens group GR4 is a thing of a four nine groups configuration which has three lenses which consist of the 7th lens L7, the 8th lens L8, and the 9th lens L9, respectively.

[0016] Moreover, it extracts between the 2nd lens group GR2 and the 3rd lens group GR3, and the cover glass CG of a low pass filter LP and the infrared cut-off filters IR and CCD is arranged for ID sequentially from the body side between the 4th lens group GR4 and the image surface IMG.

[0017] And from a body side, when it is made to perform zooming and zooming is carried out to a long focal distance edge (tele edge) from a short focus distance edge (wide angle edge) by moving the above-mentioned 2nd lens group GR2 and the 4th lens group GR4, the 2nd lens silver GR2 moves the 4th lens group GR4 to an image surface side so that an image position may be held.

[0018] In addition, it succeeds in a zoom lens 1 thru/or focal adjustment of 3 by moving the 4th lens group GR4.

[0019] The 2nd lens L2 of the single lens which has the 1st lens L1 of the single lens of the meniscus configuration which has negative refractive power, the prism P which bends 90 degrees of optical paths, and forward refractive power sequentially from a body side constitutes the 1st lens group GR1.

[0020] As for a zoom lens 1 thru/or 3, it is desirable that satisfy the following conditional expression 1 and conditional expression 2, or at least one field constitutes according to the aspheric surface among each side of **** 1 lens L1.

ndL 1 > 1.75 (conditional expression 1)

nudL 1 < 30 (conditional expression 2)

However, ndL1 is a refractive index in d line of the 1st lens L1, and nudL1 is the Abbe number in d line of the 1st lens L1.

[0021] Conditional expression 1 is for specifying the yield of distortion aberration with the 1st lens L1 which is a single lens which has the negative refractive power which constitutes the 1st lens group GR1 which has forward refractive power. If the value of ndL1 becomes out of range in being prescribed by conditional expression 1, the yield of distortion aberration will become large to the refractive power of the 1st lens group GR1 needed, and it will become impossible that is, for the aspheric surface of the 4th lens group GR4 to amend this.

[0022] Conditional expression 2 is for specifying the yield of the chromatic aberration by L1 with the 1st lens which is a single lens which has the negative refractive power which constitutes the 1st lens group GR1 which has forward refractive power. That is, if the value of nudL1 becomes out of range in being prescribed by conditional expression 2, the yield of the chromatic aberration within the 1st lens group GR1 which has forward refractive power will become large, and it will become difficult [the whole lens system] to amend this.

[0023] Moreover, as for the field S1 by the side of the body of a zoom lens 1 thru/or the 1st lens L1 of 3, it is desirable that it is a convex towards a body side. This is because the negative distortion aberration which the above-mentioned field S1 generates on this concave surface S1 as it is concave towards a body side becomes large and it becomes difficult to amend this in the lens whole system.

[0024] It is desirable that at least one field is constituted by the aspheric surface among each field of the lens which constitutes a zoom lens 1 thru/or the 4th lens

group GR4 of 3, and for at least one field of the lens especially located most in an image surface side to be constituted by the aspheric surface.

[0025] Thus, if the aspheric surface constitutes at least one field among the lens sides in the 4th lens group GR4 The negative distortion aberration in the wide angle edge generated by the 1st lens group GR1 can be amended now. By this Power of a single lens (the 1st lens) L1 which has the negative refractive power of the 1st lens group GR1 can be strengthened now, and a larger field angle can be obtained now.

[0026] Furthermore, as for a zoom lens 1 thru/or 3, it is desirable to constitute so that the following conditional expression 3 may be satisfied.

4.5<fGR1/fw<12 (conditional expression 3)

However, fGR1 is the focal distance of the 1st lens group GR1, and fw is a focal distance in the wide angle edge of the lens whole system.

[0027] Conditional expression 3 specifies the ratio of the focal distance of the 1st lens group GR1 which has forward refractive power, and the focal distance of the lens whole system. Namely, if the value of fGR1/fw becomes 4.5 or less, the forward power of the 1st lens group GR1 will become strong too much. [whether with this single lens L2, amendment of spherical aberration becomes whether to be impossible by 2nd lens L2 power which has the forward refractive power in the 1st lens group GR1 and which is a single lens becoming large, and] Or the power of the 1st lens which is a single lens which has negative refractive power will become weak, and sufficient extensive field angle-ization will become difficult. Moreover, if the value of fGR1/fw becomes 12 or more, the forward power of the 1st lens group GR1 becomes weak too much, a zoom lens 1 thru/or the overall length of 3 will become long, and a miniaturization will become difficult.

[0028] Next, the matter of the zoom lens 1 concerning the 1st thru/or the 3rd example thru/or the proper of 3 is explained.

[0029] Each numeric value of a zoom lens 1 is shown in Table 1. In addition, the field which wrote (ASP) in addition after the numeric value of Ri is constituted by the aspheric surface (the same is said also of Table 4 and 7 mentioned later.).

[0030]

[Table 1]

R1=35. 116	d1=1. 8	ndL1=1. 85000	νdL1=23. 5
R2=16. 675	d2=5. 5		
R3=∞	d3=9. 5	ndP=1. 56883	νdP=56. 0
R4=∞	d4=8. 5	ndP=1. 56883	νdP=56. 0
R5=∞	d5=0. 5		
R6=46. 847	d6=2. 8	ndL2=1. 76811	νdL2=49. 7
R7=-38. 962	d7=variable		
R8=-64. 828	d8=1. 1	ndL3=1. 84000	νdL3=43. 0
R9=14. 768	d9=1. 1		
R10=140. 620	d10=1. 1	ndL4=1. 75359	νdL4=51. 6
R11=8. 989	d11=2. 0	ndL5=1. 84666	νdL5=23. 8
R12=33. 286	d12=variable		
R13=∞	d13=1. 5		
R14=9. 334(ASP)	d14=2. 0	ndL6=1. 80610	νdL6=40. 7
R15=12. 687	d15=variable		
R16=7. 522	d16=3. 0	ndL7=1. 75955	νdL7=50. 8
R17=-40. 255	d17=1. 5	ndL8=1. 84666	νdL8=23. 8
R18=8. 007	d18=3. 3	ndL9=1. 69350	νdL9=53. 3
R19=24. 197(ASP)	d19=variable		
R20=∞	d20=1. 5	ndLP=1. 55232	νdLP=63. 4
R21=∞	d21=1. 2	ndIR=1. 51680	νdIR=64. 2
R22=∞	d22=1. 00		
R23=∞	d23=0. 75	ndCG=1. 55671	νdCG=58. 6
R24=∞	d24=1. 0		
R25=∞			

[0031] As shown in the above-mentioned table 1, in connection with zooming of a zoom lens 1, and focusing actuation, spacings d7, d12, d15, and d19 are adjustable (variable). Therefore, FNo., and f and omega are shown in Table 2 at each numeric value of d7, d12, d15, and d19 in the middle focal location (f= 9.0) of a wide angle edge (f= 5.3), a tele edge (f= 15.6) and a wide angle edge, and a tele edge, and a list.
[0032]
[Table 2]

f	5.3	9.0	15.5
FNo.	2.4	2.6	3.1
ω	37.0°	24.0°	14.5°
d7	0.8	8.38	13.76
d12	15.01	7.45	2.05
d15	7.02	4.96	2.0
d19	4.82	6.88	9.84

[0033] Moreover, the field S19 by the side of the field S14 by the side of the body of 6th lens L6 of the 3rd lens group GR3 and the image surface of the 9th lens L9 of the 4th lens group GR4 is constituted by the aspheric surface. The 4th aspheric surface coefficient C [6th / 8th / 10th] 4 of the above-mentioned fields S14 and S19, and C6, C8 and C10 are shown in following Table 3.

[0034]

[Table 3]

	κ	C4	C6	C8	C10
S14(R14)	0	-0.9142E-04	0.3775E-05	-0.4308E-06	0.1590E-07
S19(R19)	0	0.1217E-02	0.2458E-04	0.1236E-05	0.1235E-07

[0035] In addition, "E" in the above-mentioned table 3 shall mean the exponential notation which uses 10 as a bottom. (Also setting to Table 7 and 11 mentioned later the same.) .

[0036] Drawing showing the spherical aberration in the middle focal location and tele edge of a wide angle edge, a wide angle edge, and a tele edge, the astigmatism, and distortion aberration of a zoom lens 1 is shown in drawing 2 thru/or drawing 4 , respectively. In addition, in a spherical-aberration Fig., e line (wavelength of 546.1nm) and a dotted line (broken line with a shorter pitch) show a value [in / alternate long and short dash line / C line (wavelength of 656.3nm), and / d line and a broken line, and / in a two-dot chain line / g line (wavelength of 435.8nm)], and a continuous line shows a value [in / a continuous line and / in a broken line / a meridional image surface] in an astigmatism Fig. [an F line (wavelength of 486.1nm)] [the sagittal image surface]

[0037] In the above-mentioned zoom lens 1, **** of the image surface by the eccentricity within the 4th lens group GR4 is made small, and it is made to make manufacture easy by constituting the 4th lens group GR4 with the cemented lens of three lenses L7, L8, and L9.

[0038] Each numeric value of a zoom lens 2 is shown in Table 4.

[0039]

[Table 4]

R1=43.203	d1=2.0	ndL1=1.84666	ν dL1=23.8
R2=16.054	d2=4.0		
R3=∞	d3=9.5	ndP=1.56883	ν dP=56.0
R4=∞	d4=8.5	ndP=1.56883	ν dP=56.0
R5=∞	d5=0.5		
R6=40.072	d6=2.3	ndL2=1.83500	ν dL2=43.0
R7=-40.072	d7=variable		
R8=-130.120	d8=1.1	ndL3=1.83500	ν dL3=43.0
R9=11.909	d9=1.29		
R10=∞	d10=1.0	ndL4=1.75359	ν dL4=51.6
R11=7.755	d11=2.2	ndL5=1.84666	ν dL5=23.8
R12=31.164	d12=variable		
R13=∞	d13=1.5		
R14=9.845(ASP)	d14=1.5	ndL6=1.69350	ν dL6=53.3
R15=18.742	d15=variable		
R16=9.080	d16=2.5	ndL7=1.69350	ν dL7=53.3
R17=-9.050	d17=1.0	ndL8=1.84666	ν dL8=23.8
R18=-104.131	d18=4.75		
R19=35.898(ASP)	d19=1.0	ndL9=1.49200	ν dL9=57.2
R20=24.197(ASP)	d20=variable		
R21=∞	d21=1.5	ndLP=1.55232	ν dLP=63.4
R22=∞	d22=1.2	ndIR=1.51680	ν dIR=64.2
R23=∞	d23=1.0		
R24=∞	d24=0.75	ndCG=1.55671	ν dCG=58.6
R25=∞	d25=1.0		
R26=∞			

[0040] As shown in the above-mentioned table 4, in connection with zooming of a zoom lens 2, and focusing actuation, spacings d7, d12, d15, and d20 are adjustable (variable). Therefore, FNo., and f and omega are shown in Table 5 at each numeric value of d7, d12, d15, and d20 in the middle focal location (f= 9.0) of a wide angle edge (f= 5.3), a tele edge (f= 15.5) and a wide angle edge, and a tele edge, and a list.
[0041]
[Table 5]

f	5.3	9.0	15.5
FNo.	2.8	3.1	3.8
ω	37.0°	24.0°	14.5°
d7	0.8	7.17	11.4
d12	12.65	6.28	2.05
d15	8.99	6.09	2.0
d20	3.67	6.57	10.68

[0042] Moreover, the field S14 by the side of the body of 6th lens L6 of the 3rd lens group GR3, the field S19 by the side of the body of the 9th lens L9 of the 4th lens group GR4, and the field S20 by the side of the image surface are constituted by the aspheric surface. The 4th aspheric surface coefficient C [6th / 8th / 10th] 4 of the above-mentioned fields S14, S19, and S20, and C6, C8 and C10 are shown in following Table 6.

[0043]

[Table 6]

	κ	C4	C6	C8	C10
S14(R14)	0	-0.1224E-03	0.9870E-05	-0.1144E-05	0.4671E-07
S19(R19)	0	-0.9497E-03	0.3720E-04	-0.6771E-05	0.3284E-06
S20(R20)	0	-0.5412E-04	0.7292E-04	-0.8809E-05	0.4530E-06

[0044] Drawing showing the spherical aberration in the middle focal location and tele edge of a wide angle edge, a wide angle edge, and a tele edge, the astigmatism, and distortion aberration of a zoom lens 2 is shown in drawing 6 thru/or drawing 8 , respectively. In addition, in a spherical-aberration Fig., e line and a dotted line show a value [in / alternate long and short dash line / C line and / d line and a broken line, and / in a two-dot chain line / g line], and a continuous line shows a value [in / a continuous line and / in a broken line / a meridional image surface] in an astigmatism Fig. [an F line] [the sagittal image surface]

[0045] Moreover, in a zoom lens 2, the aspheric lens made from plastics is used for the 9th lens L9 of the 4th lens group GR4, and the zoom lens which can be cheaply manufactured with a miniaturization and high performance-ization is constituted.

[0046] Each numeric value of a zoom lens 3 is shown in Table 7.

[0047]

[Table 7]

R1=35.641	d1=1.8	ndL1=1.85000	νdL1=23.5
R2=18.216(ASP)	d2=5.5		
R3=∞	d3=9.5	ndP=1.56883	νdP=56.0
R4=∞	d4=8.5	ndP=1.56883	νdP=56.0
R5=∞	d5=0.5		
R6=32.208	d6=2.8	ndL2=1.76656	νdL2=49.9
R7=-56.283	d7=variable		
R8=-53.723	d8=1.1	ndL3=1.84000	νdL3=43.0
R9=17.458	d9=1.1		
R10=∞	d10=1.0	ndL4=1.84000	νdL4=43.0
R11=7.863	d11=2.0	ndL5=1.83916	νdL5=23.8
R12=48.420	d12=variable		
R13=∞	d13=1.5		
R14=18.484(ASP)	d14=2.0	ndL6=1.80610	νdL6=40.7
R15=15.006	d15=variable		
R16=7.899	d16=3.0	ndL7=1.79554	νdL7=46.8
R17=-33.011	d17=1.5	ndL8=1.80683	νdL8=25.6
R18=6.097	d18=3.3	ndL9=1.69350	νdL9=53.3
R19=22.085(ASP)	d19=variable		
R20=∞	d20=1.5	ndLP=1.55232	νdLP=63.4
R21=∞	d21=1.2	ndIR=1.51680	νdIR=64.2
R22=∞	d22=1.0		
R23=∞	d23=0.75	ndCG=1.55671	νdCG=58.6
R24=∞	d24=1.0		
R25=∞			

[0048] As shown in the above-mentioned table 7, in connection with zooming of a zoom lens 3, and focusing actuation, spacings d7, d12, d15, and d19 are adjustable (variable). Therefore, FNo., and f and omega are shown in Table 8 at each numeric value of d7, d12, d15, and d19 in the middle focal location (f= 9.0) of a wide angle edge (f= 5.3), a tele edge (f= 15.5) and a wide angle edge, and a tele edge, and a list.

[0049]

[Table 8]

f	5.3	9.0	15.5
FNo.	2.4	2.6	3.1
ω	37.0°	24.0°	14.5°
d7	0.8	8.08	13.2
d12	14.41	7.12	2.0
d15	7.26	5.11	2.0
d19	5.19	7.34	10.45

[0050] Moreover, the field S19 by the side of the field S2 by the side of the image

surface of the 1st lens L1 of the 1st lens group, the field S14 by the side of the body of 6th lens L6 of the 3rd lens group GR3, and the image surface of the 9th lens L9 of the 4th lens group GR4 is constituted by the aspheric surface. The 4th aspheric surface coefficient C [6th / 8th / 10th] 4 of the above-mentioned fields S2, S14, and S19, and C6, C8 and C10 are shown in following Table 3.

[0051]

[Table 9]

	κ	C4	C6	C8	C10
S2(R2)	0	-0. 4475E-05	0. 2083E-07	-0. 6283E-10	-0. 7920E-12
S14(R14)	0	-0. 6561E-04	0. 1709E-05	-0. 1885E-06	0. 6981E-08
S19(R19)	0	0. 1058E-02	0. 2442E-04	0. 4797E-06	0. 3475E-07

[0052] He is trying to amend the spherical aberration in a curvature of field and a long focal distance region in a zoom lens 3, by constituting the field S2 by the side of the image surface of the 1st lens L1 in the 1st lens group GR1 according to the aspheric surface, as described above.

[0053] Drawing showing the spherical aberration in the middle focal location and tele edge of a wide angle edge, a wide angle edge, and a tele edge, the astigmatism, and distortion aberration of a zoom lens 3 is shown in drawing 10 thru/or drawing 12 , respectively. In addition, in a spherical-aberration Fig., e line and a dotted line show a value [in / alternate long and short dash line / C line and / d line and a broken line, and / in a two-dot chain line / g line], and a continuous line shows a value [in / a continuous line and / in a broken line / a meridional image surface] in an astigmatism Fig. [an F line] [the sagittal image surface]

[0054] In the above-mentioned zoom lens 3, like the zoom lens 1 in the 1st example, **** of the image surface by the eccentricity within the 4th lens group GR4 is made small, and it is made to make manufacture easy by constituting the 4th lens group GR4 with the cemented lens of three lenses L7, L8, and L9.

[0055] Each numeric value for searching for the zoom lens 1 the conditional expression 1 of 3 thru/or the monograph affair of 3 shown in the above 1st thru/or the 3rd example and the value of a monograph affair type are shown in following Table 10.

[0056]

[Table 10]

実施の形態	ndL1	νdL1	fGR1	fw	fGR1／fw
1	1.85000	23.5	38.29	5.3	7.22
2	1.84666	23.8	32.99	5.3	6.22
3	1.85000	23.5	36.94	5.3	6.97

[0057] As conditional expression 1 thru/or the conditions of 3 are satisfied and it is shown in each aberration Fig., in the middle focal location and tele edge of a wide angle edge, a wide angle edge, and a tele edge, various aberration is also amended with sufficient balance by a zoom lens 1 thru/or 3, so that clearly also from the above-mentioned table 10.

[0058] Thus, the field angle in a wide angle edge is suitable for a zoom lens 1 thru/or 3 as 74 degrees and an object for digital still cameras which used the image sensor with many pixels especially since various aberration was also fully amended good including the wide angle field.

[0059] In addition, it passes over no the concrete configurations and structures of each part which were shown in the gestalt of said operation to what showed a mere example of the somatization which hits carrying out this invention, and the technical range of this invention is not restrictively interpreted by these.

[0060]

[Effect of the Invention] So that clearly from the place indicated above this invention zoom lens The 1st lens group which has forward refractive power in order from a body side to an image surface side, and the 2nd lens group which has negative refractive power, In the zoom lens which was made to perform zooming by consisting of the 3rd lens group which has forward refractive power, and the 4th lens group which has forward refractive power, and moving the above-mentioned 2nd lens group and the 4th lens group Since the 2nd lens of the 1st lens of the single lens which has negative refractive power for the 1st lens group sequentially from a body side, the prism which bends an optical path, and the single lens which has forward refractive power constituted the optimal variable power ratio for small image pick-up devices, such as a video camera and a digital still camera, -- an about 3-time zoom lens can be miniaturized.

[0061] Since it was made to satisfy the monograph affair of ndL1 > 1.75 and nudL 1 < 30 if it was in the zoom lens indicated to claim 2 when ndL1 was made into the refractive index in d line of the 1st lens and nudL1 was made into the Abbe number in d line of the 1st lens, the distortion aberration and chromatic aberration which are generated by the 1st lens group can be amended good.

[0062] If it was in the zoom lens indicated to claim 3, since the aspheric surface constituted the field of at least 1 of the 1st lens, the spherical aberration in a

curvature of field and a long focal distance region can be amended good.

[0063] If it was in invention indicated to claim 4 thru/or claim 6, since the field it turned [field] to the body side of the 1st lens was made into the convex, the negative distortion aberration from which amending in the lens whole system becomes difficult does not become large.

[0064] If it is in invention indicated to claim 7 thru/or claim 12 Since the aspheric surface constituted the at least 1st of each sides of the lens which constitutes the 4th lens group Since the negative distortion aberration in the wide angle edge generated from the 1st lens group 2 can be effectively amended now, it becomes possible to strengthen power of the negative single lens of the 1st lens group, and a larger field angle can be obtained.

[0065] Since it was made to satisfy the conditions of 4.5<fGR1/fw<12 if it was in invention indicated to claim 13 thru/or claim 24 when fGR1 was made into the focal distance of the 1st lens group and fw was made into the focal distance in the wide edge of the lens whole system, amendment of spherical aberration, the formation of sufficient extensive field angle, and a miniaturization can be attained.

[Translation done.]